Analysis of Steel Structures with the Use of Fluid Viscous Damper for Different Plan Aspect Ratios As Per Is 1893:2016 - A Literature Review

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Abstract— Earthquake produces huge impact in terms of life, money and failure of structure .From the study of past earthquakes, it has been concluded that conventional structure disintegrate or got damaged during ground shaking. Hence it is very essential to design the structure to prevent from such earthquakes. Now a day, the seismic protection using passive controlling devices become more admired by using seismic dampers. From previous research it has been observed that one of the most admired dampers which can be easily used is fluid viscous damper due to its efficiency in controlling inter story drifts, floor acceleration and other structural parameter. It also acts like a shock absorber which dissipates more energy during strong ground motion. Various researches have been carried out for enhancing the effectiveness of seismic control system and there methodology. The aim of this study is to observe the behaviour of such passive controlling devices for seismic control for different aspect ratio of building at different positions and find its sustainability and is to review technologies for seismic control.

Keywords: Fluid Viscous Damper (FVD), Aspect Ratio, Seismic analysis, Base Shear, Drift, Displacement, IS 1893 – 2016

I. INTRODUCTION

There is a huge demand in multi-story building due to population rise in recent years; the safe factor of the structure is to be considered, as the number of stories goes high especially in terms of seismic activities [1-4]. Since the seismic forces are un-predictable and causes heavy damage during its occurrences, it is necessary to know the structural behaviour and reactions during an Earthquake. This can be accurately studied by using modern engineering tools such as software and imaginary satellite.

Nowadays rapid growth in population an industries space demand getting increasing which leads to high rise building in cities ,Also we have to construct the buildings in seismic zones .hence its necessary to design our building structure seismic forces using some suitable techniques like seismic energy dissipating devices ,base isolation. seismic control techniques are accepted all over globe. it can be used as retrofitting purposes to provide flexibility to the structure. Dampers are available in wide varieties in the markets. One of the most popular dampers is fluid viscous damper because of enhancing performance and significant energy reduction.

A. Fluid Viscous Damper (FVD)

In recent years fluid viscous damper is fused in more Earthquake resistant buildings. Fig 1 shows the schematic representation of viscous damper. When the damper is applied externally in the piston rod, it produces a damping effect through 'to and fro' medium. The friction force occurs in the piston, shaft and cylinder damping force is compost. The conventional damping force of VFD is imposed by,

$$F = CV^{\alpha}$$

Where F is the damping force, C is the damping coefficient; v is the velocity of the piston and α is the damping.

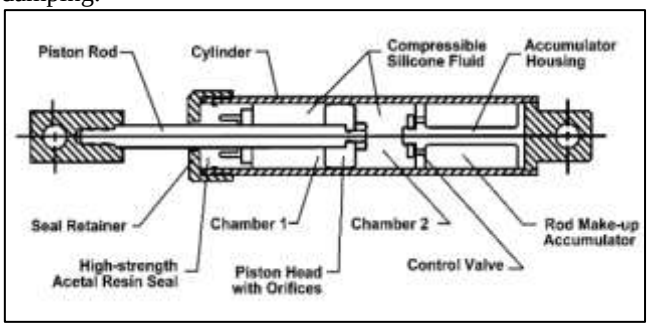

Fig. 1: Fluid Viscous Damper (FVD)

The reason for getting the popularity of FVD is its capability increasing damping of structure .it provides additional damping to structure without increasing forces in members.

II. OBJECTIVES OF THE STUDY

Structural stability is a useful parameter which is responsible to co-relate the seismic elastic response of RC structures. To design such kind of structures which will sustain in severe earthquakes in various earthquake prone zones and which will lead to reduce the harm of catastrophic as well as economic losses. Various studied carried out using damper in SMRF frames, toggle bracing system. Some research work focus on laboratory test using dampers. Various studies carried out using computer based programming software. Several studied focused on optimum placement of damper to reduce seismic performance and focused on cost as well .some researcher studied on selecting damper properties such as damping coefficient, velocity exponent, stiffness. The objective of this paper is to review technologies for seismic control using FVD and introduced some literature review till now.

III. LITERATURE REVIEW

There were various studies which have been conducted on the static and dynamic analysis and design of such structures with different types of damper. The studies also suggests about the difficulties arise for the seismic design of high rise building where such situation occurs. Few of the data from previous studies have been discussed here along with the methodology adopted and conclusions. Many research investigations have been carried out regarding the use of dampers like FVD in the multi-storey structures.

Soheila Kookalani et al(2020)A comparative Study carry out on the impact of various Fluid viscous damper parameters on the structures under the earthquake. In this a seven-story steel frame structure retrofitted with fluid viscous dampers was considered for analyzing with a variety of parameters. resulted that installing longitudinal nonlinear Fluid viscous damper can significantly reduce the seismic response by selecting reasonable damping parameters, including stiffness, damping coefficient, and velocity exponent. The optimum damping parameters has been calculated accurately by analyzing structure with different damping parameters of nonlinear Fluid viscous damper.

S. Lakshmi shreenbanu et al (2019)10 story building with or without damper created as per IS: 1893-2002 for study. Four modes were taken 1.square building square column 2.square building rectangular column 3.rectangular building square column 4.rectangular building rectangular column.tie history for Bhuj earthquake has been defined in software ETABS 2016.all four building are modelled with or without damper and finally found that 75% reduction in base shear after time history also considerably reduction in roof displacement, story Drift etc.

Ahmad sepeheri et al(2018)In this paper seismic deign and assessment of structure using FVD at limit state level has studied. A procedure is carried out to mitigate devices damages during strong earthquakes .for study there were 15 special moment resisting frame with different number of stories considered the software use for this is OPENSEES for study limit state behaviour of FVD .

Ak.Sinha et al(2017)The study carried out taking two model one is of having 12 stories moment resisting frame without damper and another with damper Analysis was done sing ETABS Software. The selected type of damper is of nonlinear type. Nonlinear time history is carried out for analysis. The velocity exponent for damper is taken as 0.5 to limit damping force from past studies. Conclude that due to increase in seismic mass because of additional damper which leads to increase base shear value.

Abdelouahab Ras et al(2014) Analysis performed on 3D 12 story steel building ,numerical observation taken on it. Nonlinear FVD are installed diagonally inside the frame. a comparative study done using two model using software SAP2000.one model is without braced and second one with braced FVD.A fast nonlinear time history performed for analysis. Modelling of FVD was carried out using mathematical expression for different values of velocity exponent. It was found that decrease in amplitude value increases the value of damping ratio for value of alpha less than one. Finally concluded that diagonals do not transmit any undesired axial forces but reduces damping compared to un braced model.

Giuseppe et al (2014) A study carried out on the behaviour of the moment resisting steel frame to seismic forces using viscous dampers. Iterative procedure is adopt to select the suitable dampers to protect structure against seismic data records . The comparative study between three different types of steel frames 3storey, 4 storey of 3bays and 12 storey of 5 bay with two types of dampers (hysteretic and viscous) installed in the middle bay which is subjected to 7 ground motions records was carried out to evaluate dynamic analysis to improve performance of the structure. The results shows that by using dampers the collapse mechanism of medium and high rise building was improved compared to bare frame, but for low rise case, this condition not satisfied.

H.kit Miyamoto et al,(2013)Studied using four story commercial building. For 3D mathematical models SAP Software is used. Nonlinear fvd is used to control stories drift .Nonlinear time history performed to determine performance. Two levels of seismic hazards investigated first (MCE) and second one (DBE).finally the maximum response quantities such as displacement, acceleration, and story shear evaluated.

Ying Zhou et al,(2012)In this paper Retrofitting of 7 stories building carried out in two stages having damaged infill walls and Cracked column beam joints. A parametric study is done for finding damping exponential value and damping coefficient. After on study its confirm that damping capacity of damper increases for both the values of damping coefficient ‘c’ and exponential value alpha. In this study stiffness of braces are taken 3 times greater than damper stiffness. In second stage, structure was tested against Drift values, Deformation values. Finally suggested that method adopted in this paper are suitable for major, moderate, minor Earthquake.

A. Munir et al, (2011) Deals with inelastic seismic demand of high rise buildings. For that they did an investigation on 40 storey residential high rise core wall building and compared it with its modal with suitable control measures. ETABS of version 9.0is used for creating model of the case study building as a linear elastic form and analyzed .A nonlinear time history analysis (NLTHA) was performed for maximum earthquake by applying 7 time history records. Another model created in PERFORM 3D software version 4 For NLTHA. Later 24 nonlinear FVD were placed in X direction as a control measures to reduce seismic demand of structure and damping force. Reduction in values of base shear, moment demand at foundation level and middle level of building was observed by 27%, 12% & 26% respectively. Inelastic behaviour of high rise buildings with shear walls explained well in this paper.

Xue-Wei Chen et al (2010) studied the seismic response of the 4 storey Wenham hospital located in china using viscous damper. The aim of the design of study was to reduce the response of the structure. For that, hospital building with and without installed viscous dampers in the concrete frame structure was carried out under various levels of seismic vibrations. ETABS software is used to carry out static pushover and nonlinear time history analysis. Displacement at top, Storey drift, and damage of the structure got controlled by adding viscous damping. Internal force values increased due to addition of K-braced damping systems raised the stiffness of the structure. But in plastic condition of structure, it gets reduced along with deformation.

Yukihiro Tokuda1 and Kenzo Taga et al(2008) Recently viscous-type, seismic energy dissipation type devices have been well developed and have come into wide use in Japan, resulting in increase in use of such devices as oil dampers for high-rise buildings and for seismically isolated buildings. In this study the viscous type devices have been employed by focusing on the fact that viscous type device is superior to hysteresis type device in that viscous type devices display damping effect even under minor or moderate earthquakes. In that the viscous type devices

display stable performance for assemble deformation. It is expected that energy absorption devices such as oil dampers are effectively incorporated to improve the earthquake resistance will be used more widely in the future. This paper introduces a practical case of "intensive vibration control structure on the first story" as a "technique to dissipate the energy efficiently and securely".

JinkooKIM,Chang-YongLEE et al(2003) If energy dissipating devices, such as base isolators, viscous or viscous-elastic dampers, are added to a structure, it turns to so called a non proportional or a non classical damping system, and cannot be analyzed by the efficient mode superposition method based on real valued Eigen values and mode shape vectors. Although direct integration method provides exact solution for the non proportional damping system, the time and memory space required for the analysis prevent the method from being used for a practical application. In this research, a non-proportionally damped structure with added viscous-elastic dampers are analyzed for earthquake excitations by the complex mode superposition method, and the results are compared with those obtained from the approximate methods such as the direct integration method with matrix condensation, modal strain energy method, and the method neglecting the off-diagonal terms of the transformed damping matrix. According to the results, the complex mode superposition, with the advantage of using only a few dominant modes turn out to be very efficient procedure of analyzing the non proportionally damped structure added with viscous elastic dampers. The direct integration method combined with the matrix condensation technique also provides seismic responses with a reasonable accuracy. It is also found that the discrepancy between the exact solutions and the results from the approximate methods increases as the damping contributed by the addition of viscous elastic dampers increases, and as the dampers is non-uniformly placed.

D.Lee et al (2001) A detailed summary given on working method of FVD, installation method, and its future scope. In this paper effect of linear and non linear damper and their relationship studied. Various software like SAP and ETABS used for modelling of dampers was suggested for seismic response reduction purposes. Also describe various bracing method of installing dampers.

M.D.Symans and M.C.Constantinou et al (1998) focussed on FVD. In this study behaviour of FVD are examined by steady state cyclic test .Analytical study carried out to using damper to evaluate seismic response of scale-model building. Generalise different SDOF model to study linear and nonlinear behaviour of FVD. Finally a comparative study on values of stiffness damping coefficient obtain analytically and experimentally. At the end concluded that FVD are effective in response reduction in story shear forces, story Drifts in the structure.

IV. CONCLUSION

The Seismic Control of RC and steel Structure using FVD Reviewed by Briefly Summarization. This study clearly indicates the capability and importance of FVD in modern buildings. It plays important role to reduce the seismic response of the structures, also plays an important role by minimizing the inter-storey drifts, overturning moments, base shear, axial forces etc. with desirable cost. While on comparing with other types of dampers, FVD has more efficiency due to which its life is almost near to design life of building structure which can minimize the maintenance cost for dampers. Different configuration for FVD [chevron, toggle, base plate, K-type Diagonal Bracing] provides ease of installation in any desired shapes and position of the bare frame models with effective functioning. It's also observed that for the seismic response reduction of high rise building, nonlinear FVD with $\alpha < 1$ is effective as compare to linear damper $\alpha = 1$.

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